



Cost/Performance Comparisons of Alternative Cooling Systems

**John S. Maulbetsch
Kent D. Zammit**

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Water Savings

- ⊕ Wet system

- 10 to 12 gpm/MW for cooling

- ⊕ Dry systems

- ~ 0 gpm for cooling

- ⊕ For 500 MW combined-cycle @ 80% capacity factor

- Difference = ~3,000 acre-feet/year

- ⊕ For 500 MW coal plant @ 80 % capacity factor

- Difference = ~6,000 acre-feet/year

At what price?

⊕ It all depends.....

Methodology is more important than pricing

How to compare

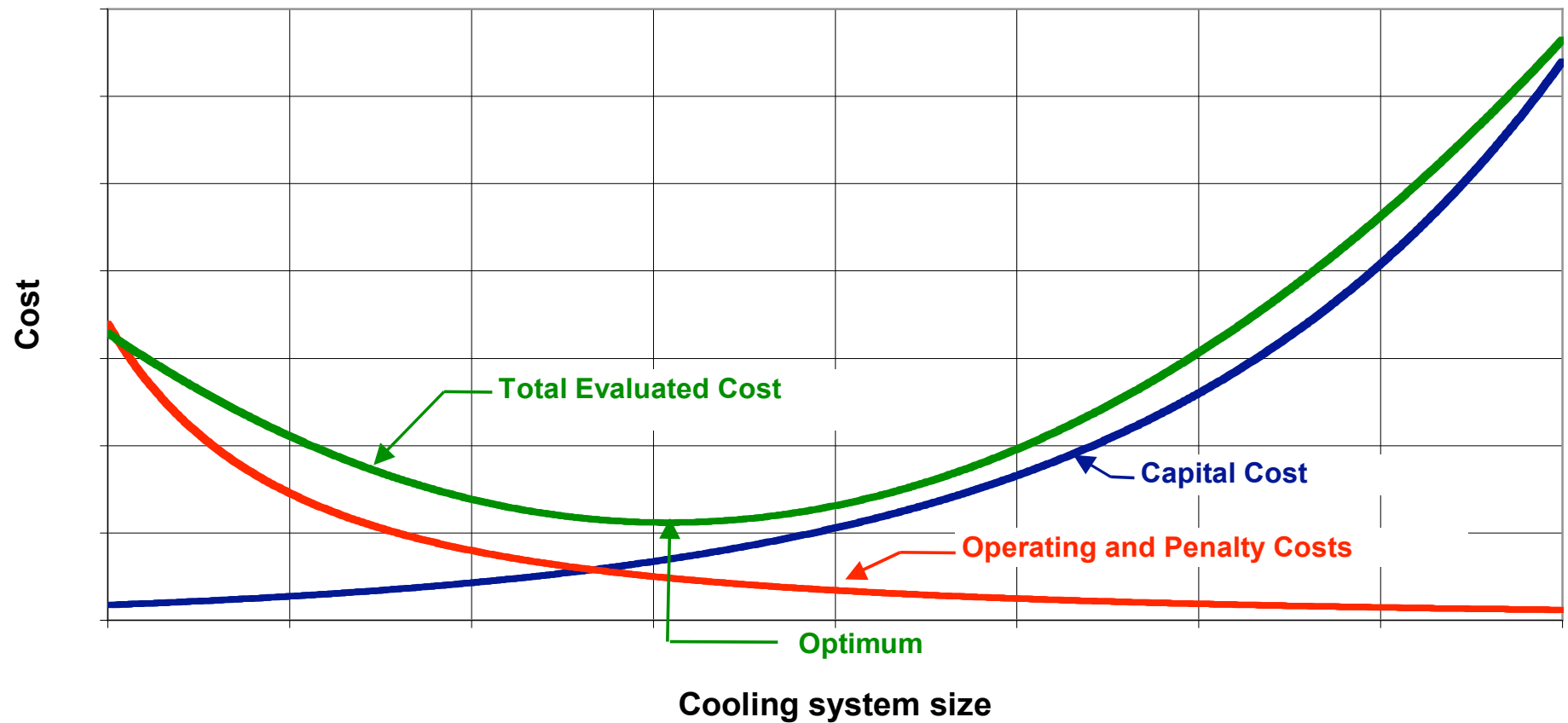
- ⊕ Compare optimized systems
- ⊕ Include all costs affected by cooling system choice

What are all costs?

- ⊕ Equipment
- ⊕ Cooling system power requirements
- ⊕ O & M costs
- ⊕ Plant efficiency
- ⊕ Plant output
- ⊕ Water
 - Acquisition
 - Delivery
 - Treatment
 - Discharge

What is optimized?

Tradeoffs

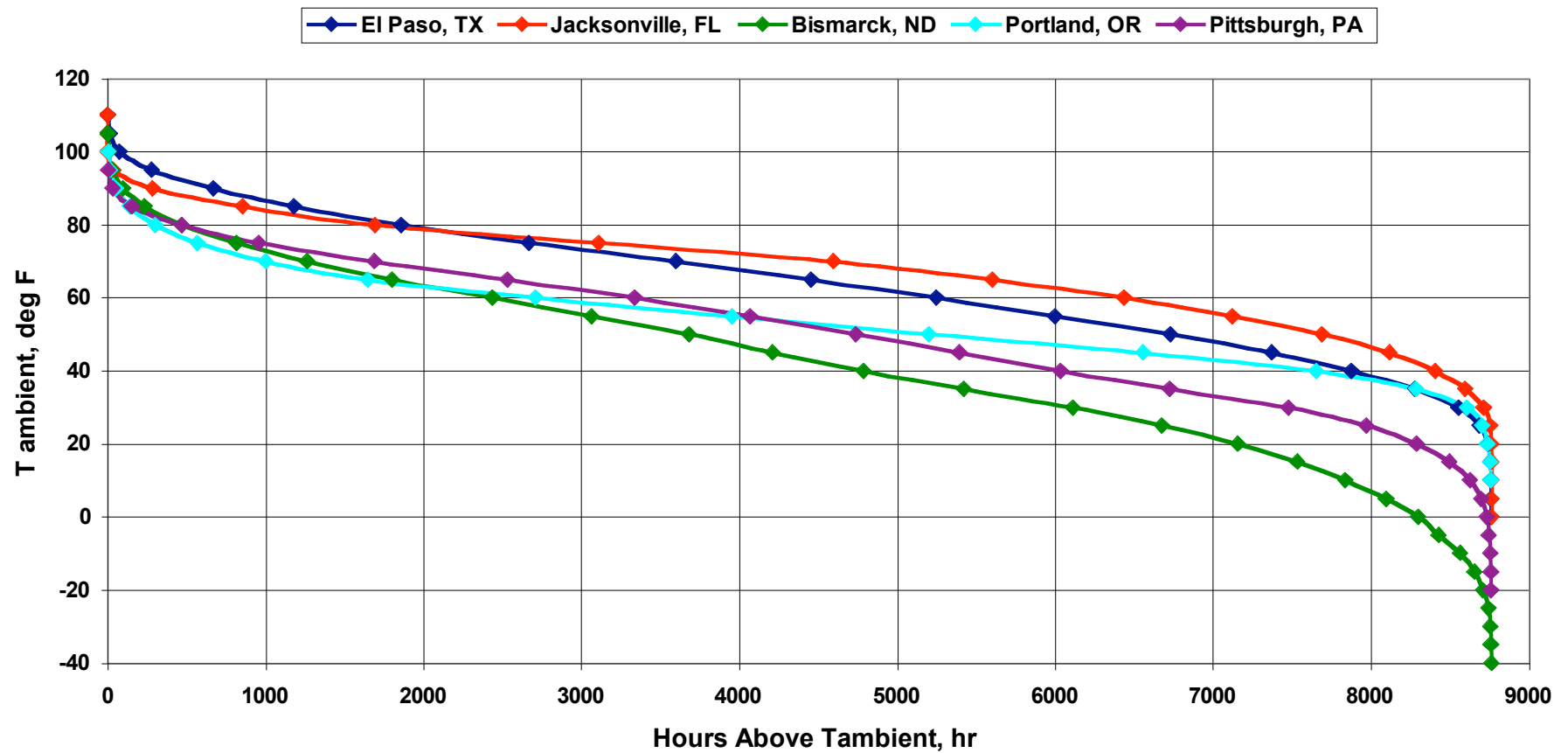


What affects the optimum costs?

- ⊕ Site characteristics
 - Temperature
 - Elevation
 - Wind
- ⊕ Plant characteristics
 - Heat rate vs. backpressure
 - Operating profile
- ⊕ “Business” characteristics
 - Regulated vs. non-regulated
 - Economic expectations
 - Peak vs. average pricing

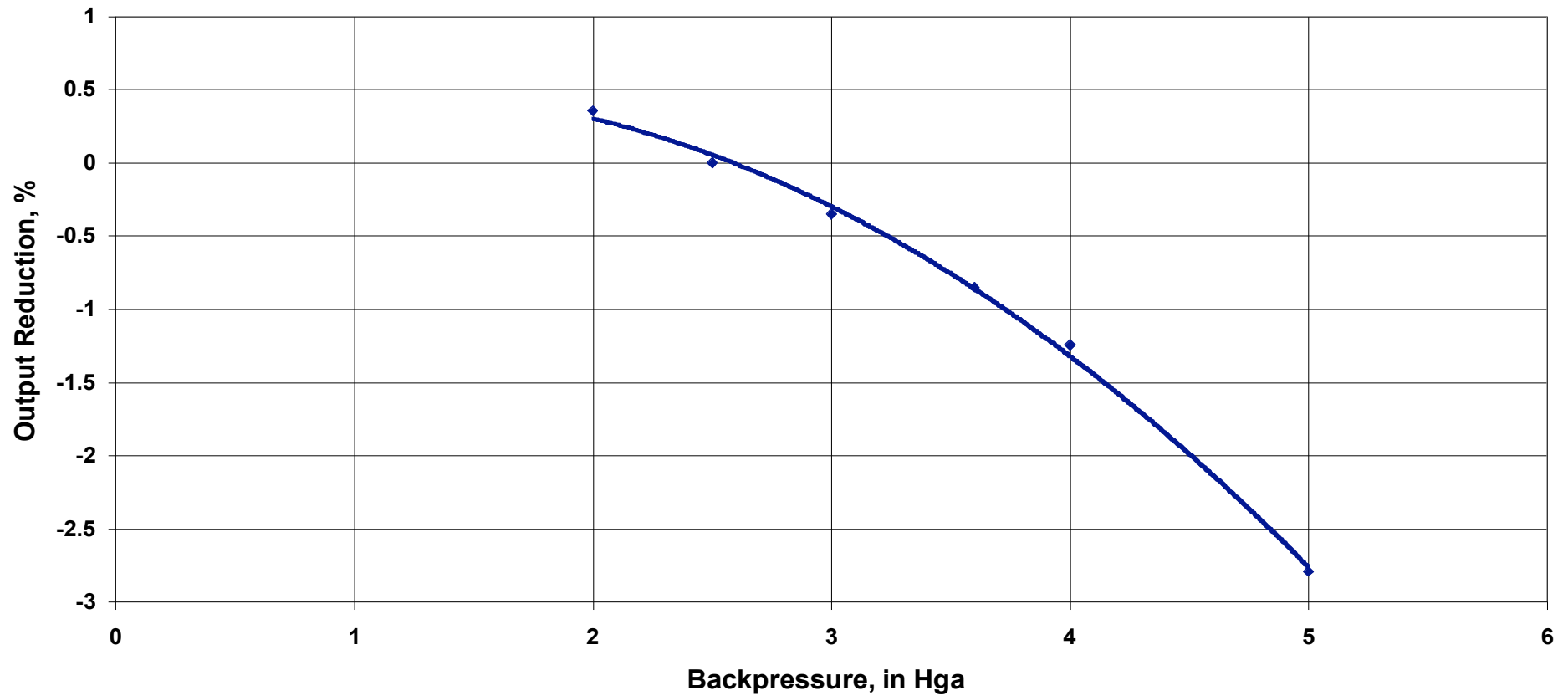
Site Temperature

Temperature Duration Curves



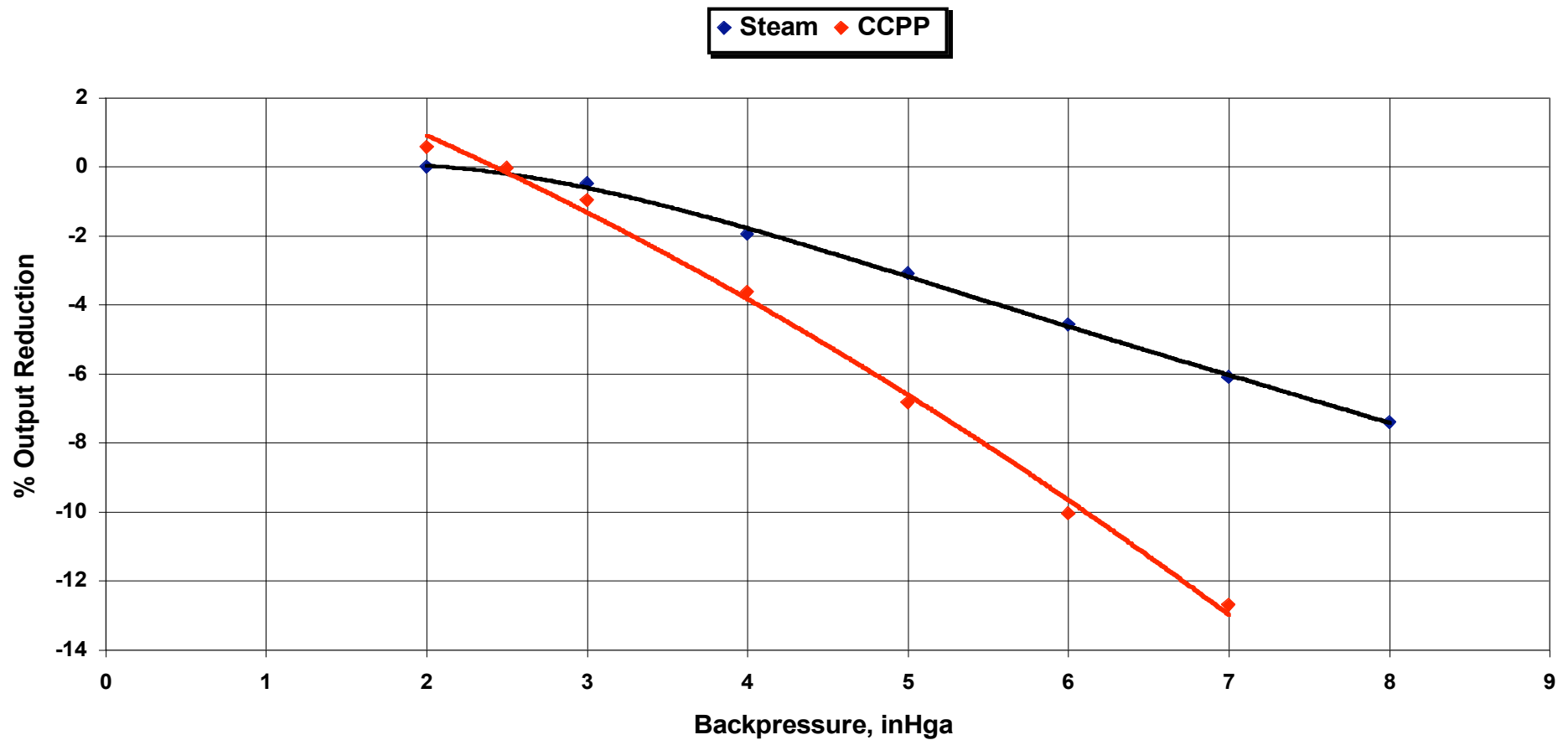
Plant Heat Rate Curve

Output Correction Curve--Conventional Turbine

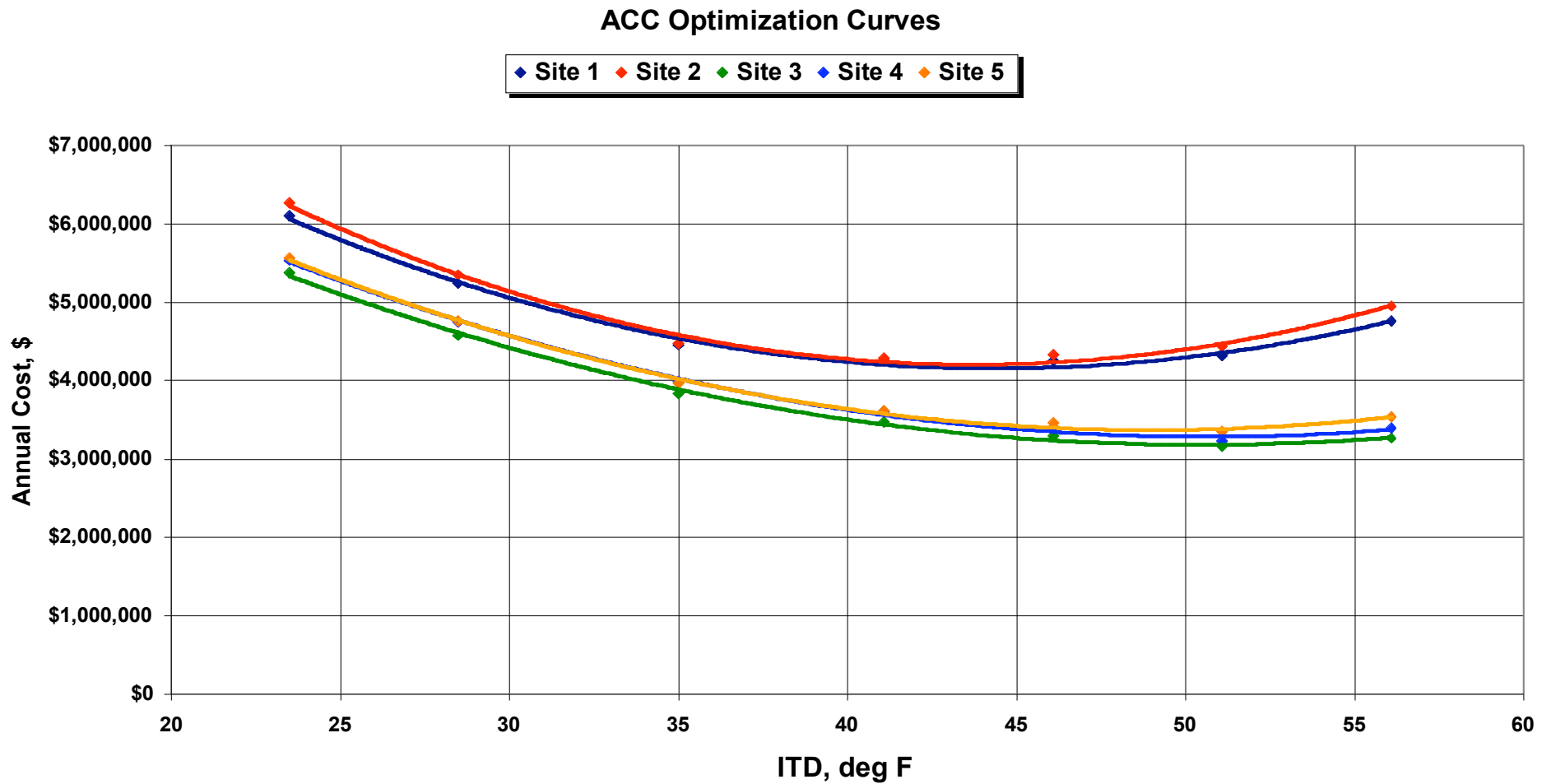


Extended back-pressure turbines

Output Correction Curve Comparison

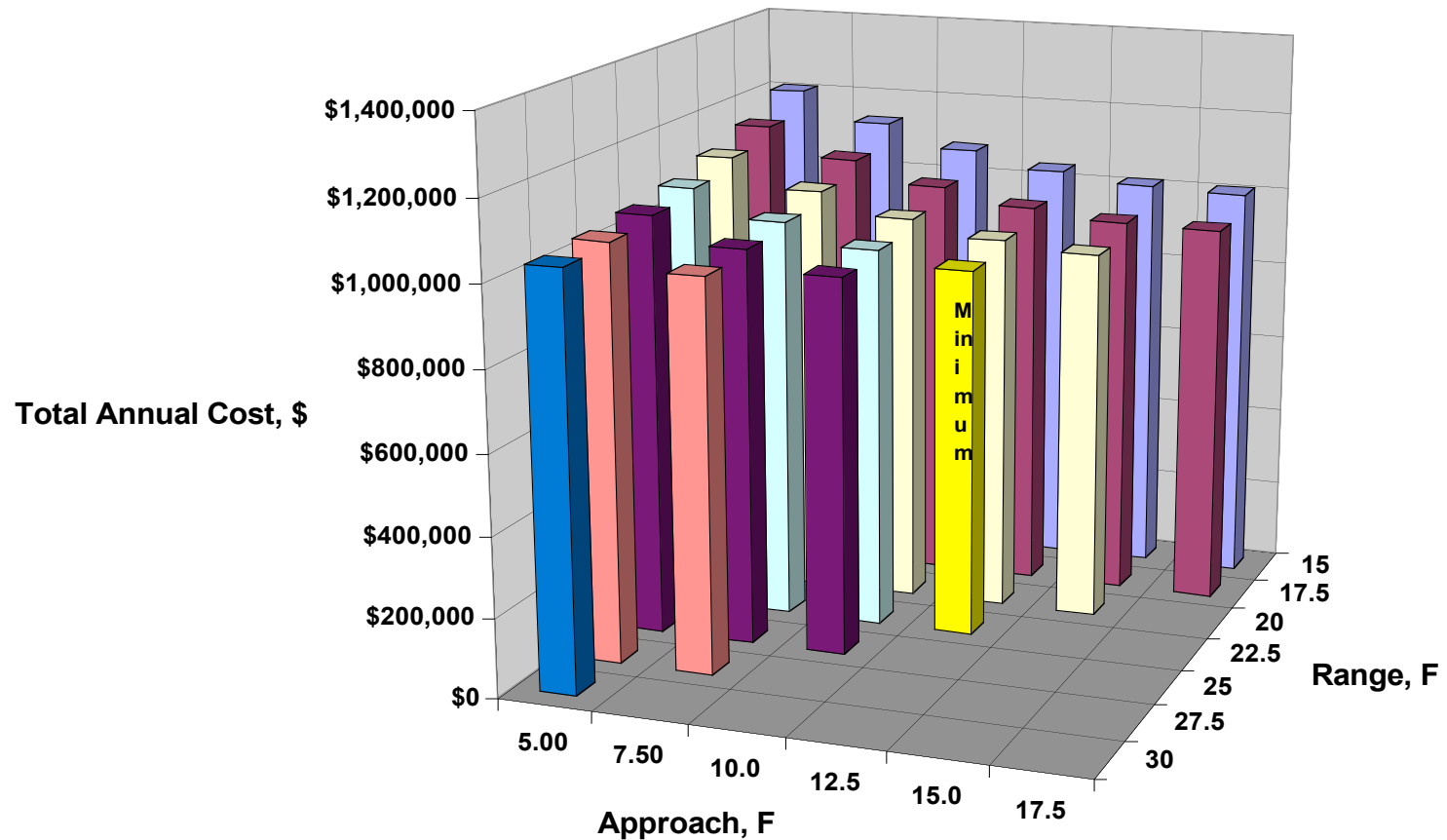


Annual Cost Optimization



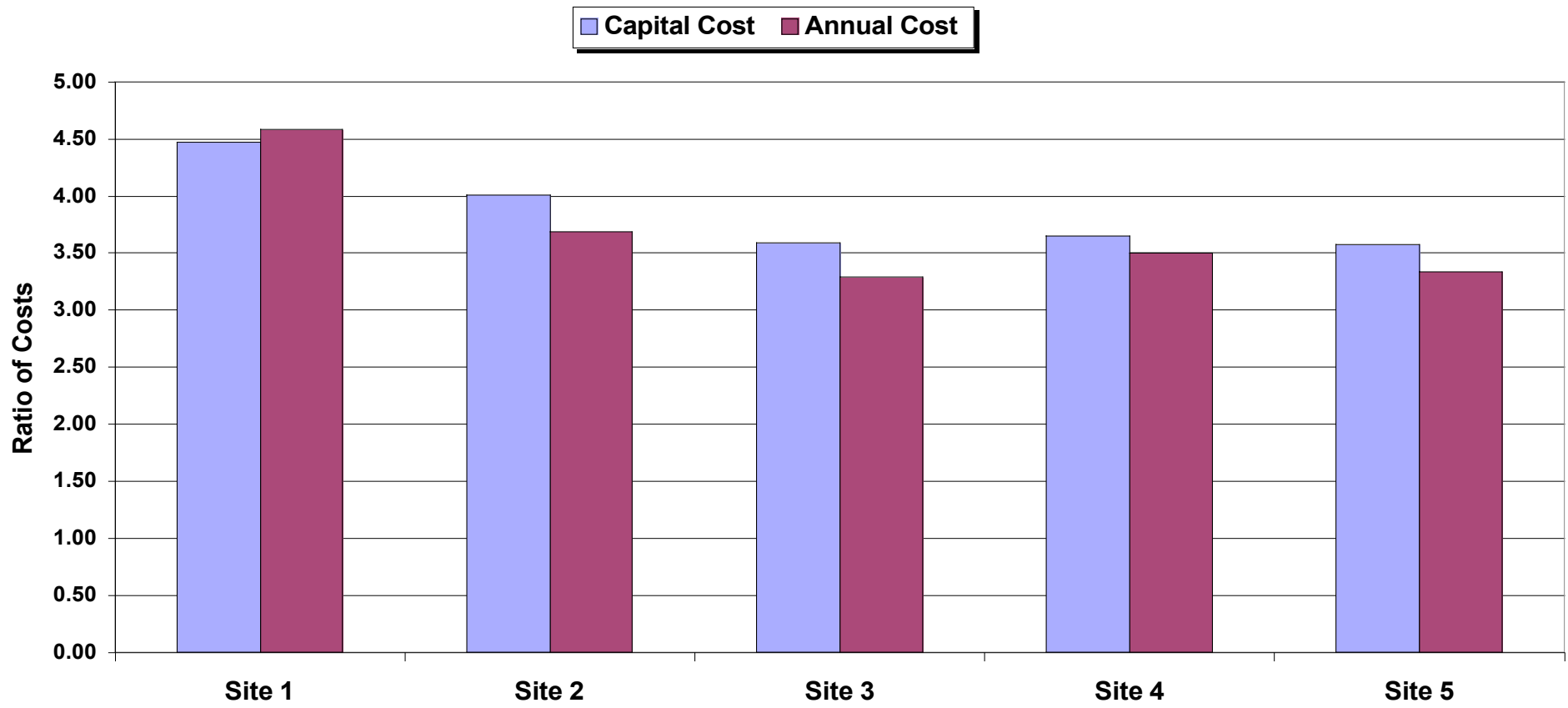
Wet System Optimization

Site 1---Annual Cost Comparisons

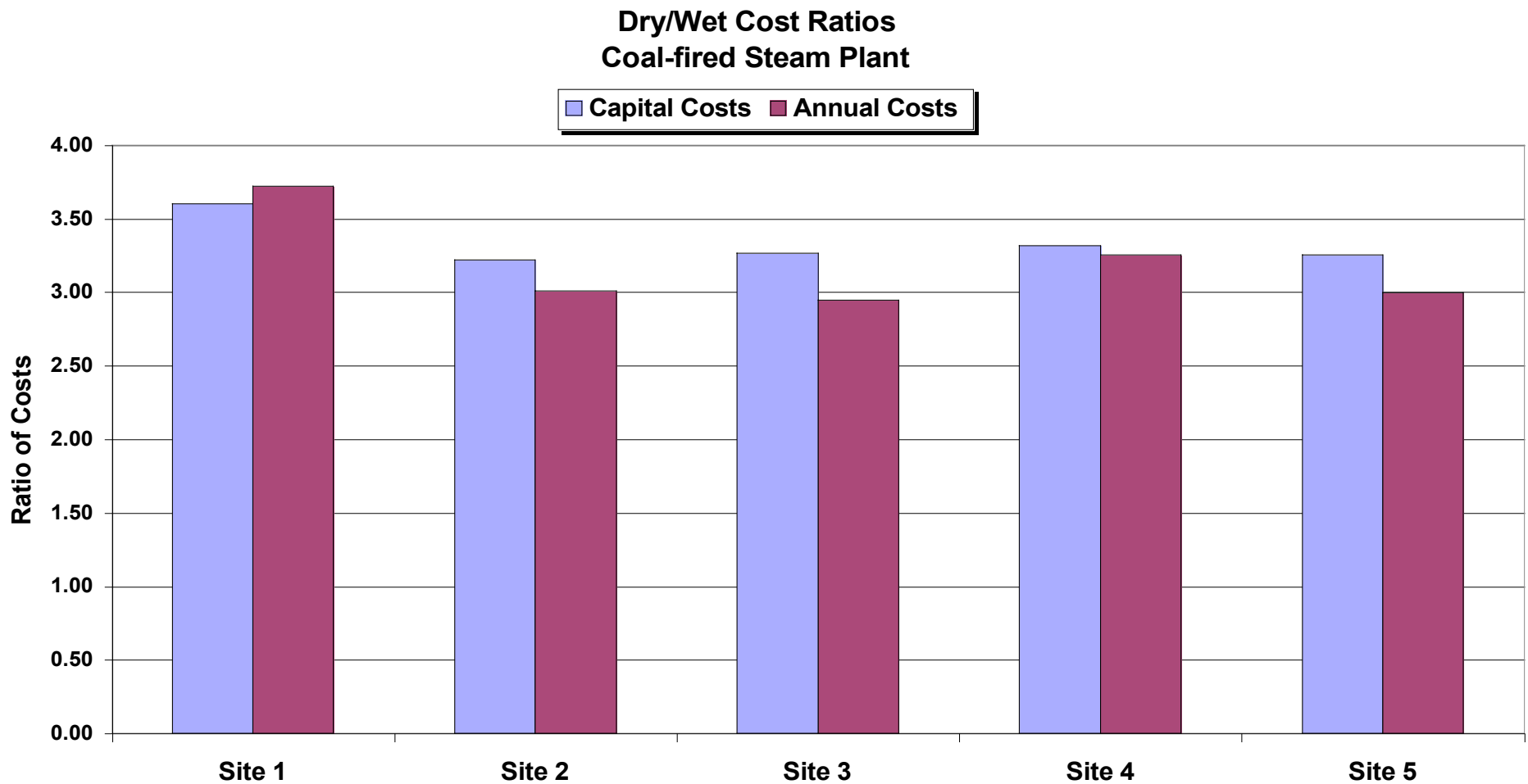


Cost Ratios--- Combined Cycle Plants

**Dry/Wet System Cost Ratios
Gas-fired Combined-cycle Plant**



Cost Ratios--- Coal Plants



Water Costs

Costs	Minimum	Low	Medium	High
	\$/1,000 gallons	\$/1,000 gallons	\$/1,000 gallons	\$/1,000 gallons
Acquisition	Nil	\$0.50	\$1.25	\$3.00
Delivery	Nil	\$0.13	\$0.57	\$1.20
Treatment/Disposal	\$0.10	\$0.22	\$1.00	\$4.28
Total	\$0.10	\$0.85	\$2.82	\$8.48

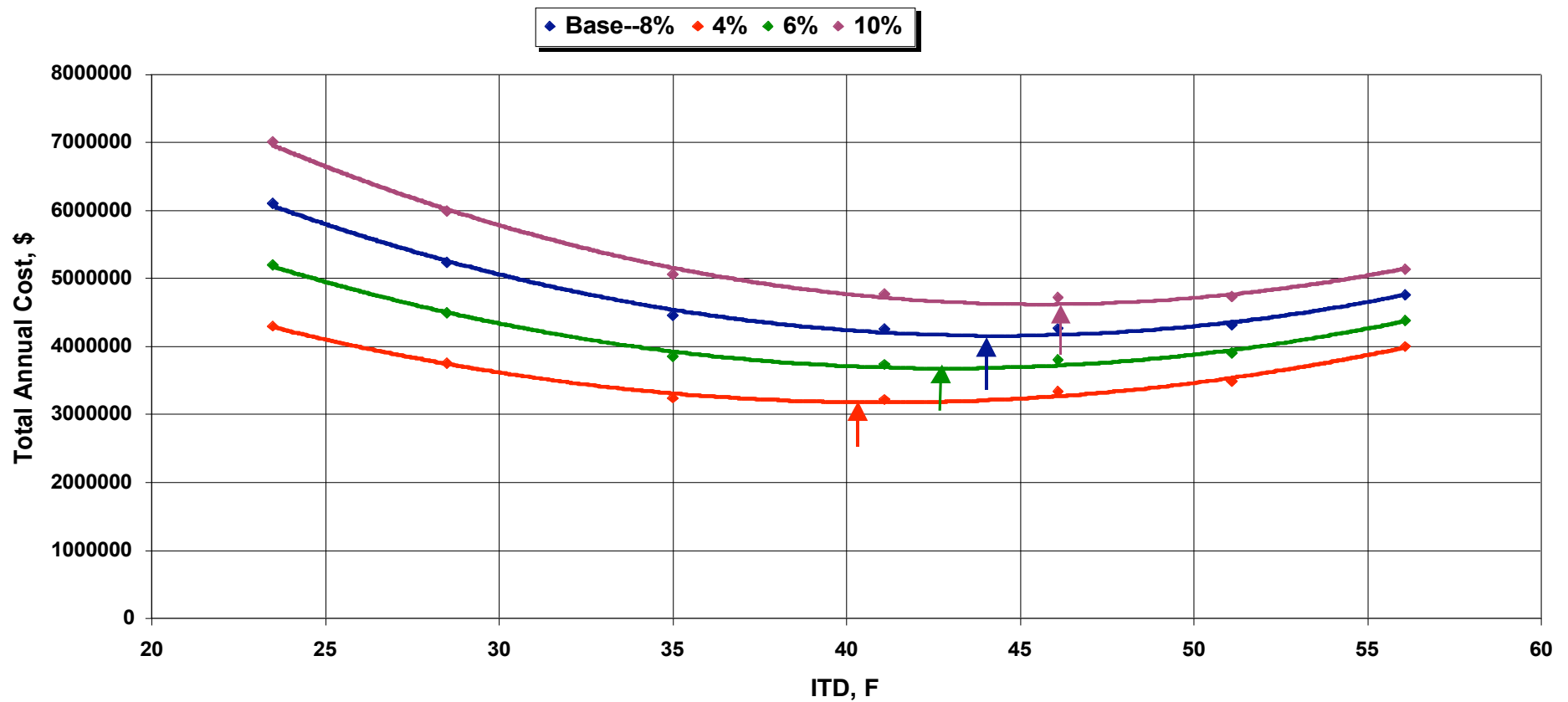
Effect of Water Costs

Annual Cost Ratios vs. Water Cost



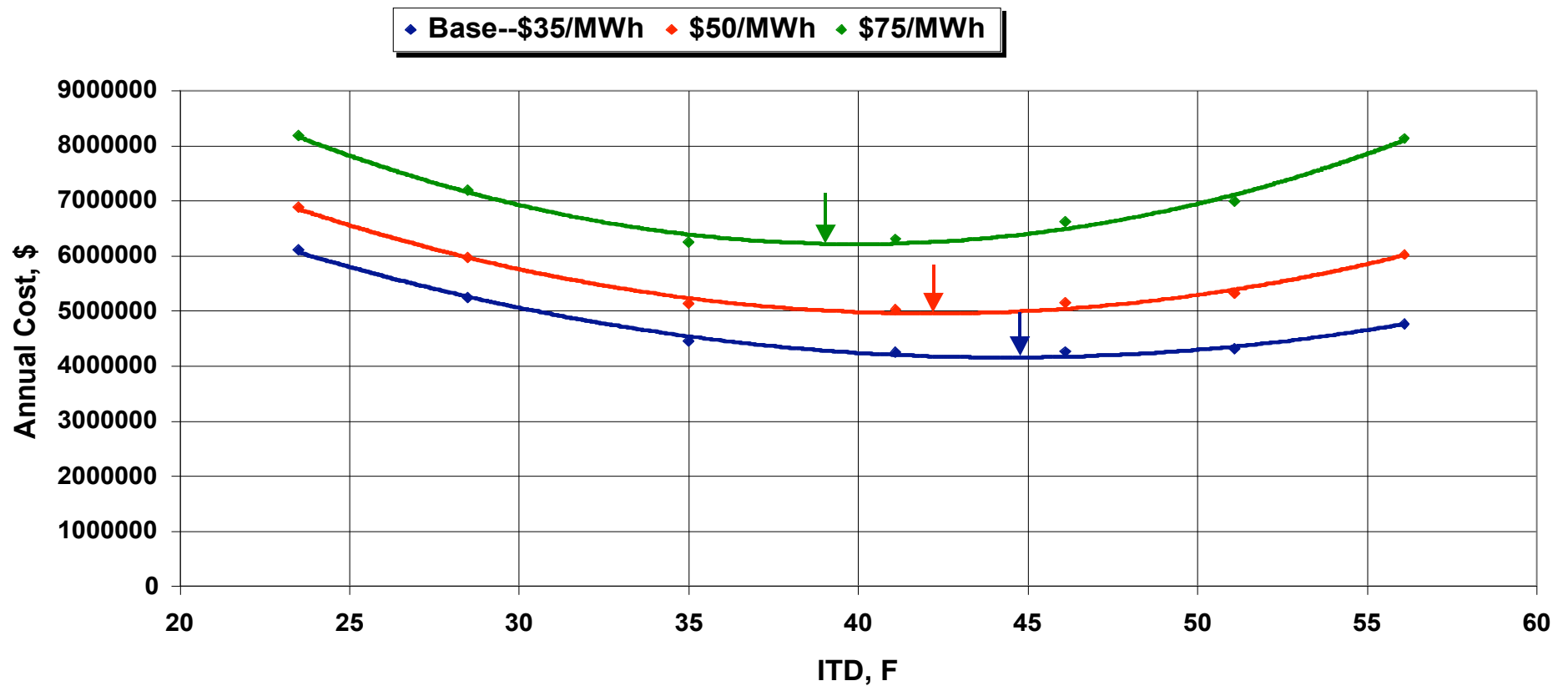
Amortization Factor

Effect of Amortization Rate



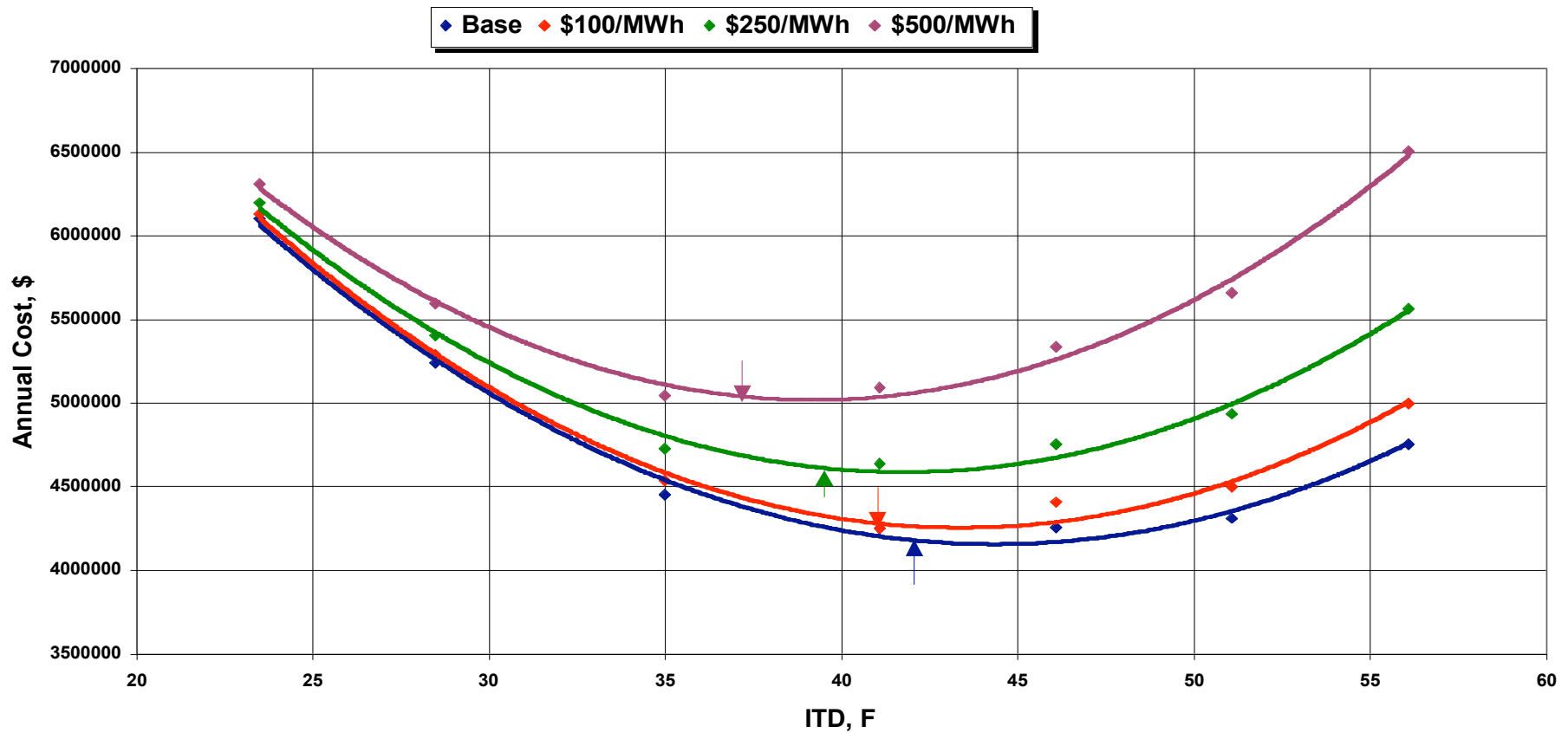
Effect of Average Power Price

Effect of Year-Round Power Price--Site 1

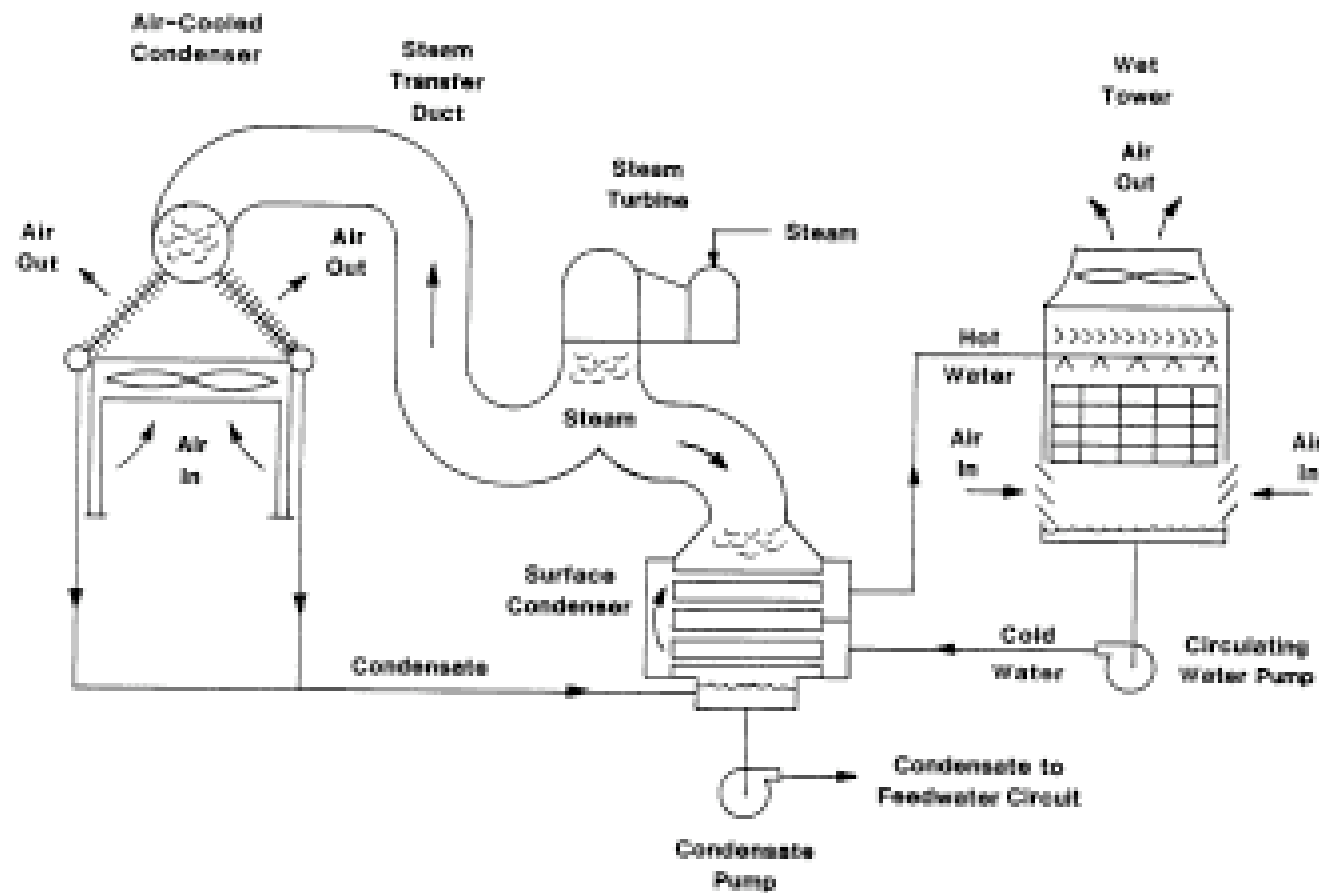


Effect of Peak Power Price

Effect of Peak Period Power Prices on ACC Optimization
Site 1---Hot, arid



Wet/Dry System



Summary

✓ Water savings

- 500 MW CCPP ----- ~900 million gallons
- 350 MW coal plant ----- ~2 billion gallons

✓ Cost ratios

- Capital cost ----- 3.5 to 4.5
- Plant output reduction (hot, arid site)
 - Hottest hour ----- ~25%
 - Hottest 1000 hours ----- ~8%
 - Annual average ----- ~2%

⊕ Breakeven water cost

- \$3.50 to \$4.50/1,000 gallons